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PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
TANG, Henry
Baker & Botts, LLP
30 Rockefeller Plaza
New York, NY 10112-0228
ETATS-UNIS D'AMERIQUE

BAKER BOTTS L.L.P.
00 OCT 10 PM 12:47

HYT

Date of mailing (day/month/year) 28 September 2000 (28.09.00)	
Applicant's or agent's file reference 32038-PCT	**IMPORTANT NOTICE**
International application No. PCT/US99/06384	**International filing date** (day/month/year) 23 March 1999 (23.03.99)
	Priority date (day/month/year)
Applicant THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK et al	

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   CA,JP

   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   28 September 2000 (28.09.00) under No. WO 00/57323

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

COPY TO
HYT 10/12/00

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer J. Zahra
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

Form PCT/IB/308 (July 1996)

3537985

11/23/00
Deadline

ATENT COOPERATION T[illegible] Y

32038
PC

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

99 MAY 21 AM 9:53

TANG, Henry
Baker & Botts, LLP
30 Rockefeller Plaza
New York, NY 10112-0228
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing (day/month/year)	IMPORTANT NOTIFICATION
03 May 1999 (03.05.99)	
Applicant's or agent's file reference	**International application No.**
32038-PCT	PCT/US99/06384

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK (for all designated States except US)
SEMRET, Nemo et al (for US)

International filing date	:	23 March 1999 (23.03.99)
Priority date(s) claimed	:	
Date of receipt of the record copy by the International Bureau	:	23 April 1999 (23.04.99)
List of designated Offices	:	

National :CA,JP,US

ATTENTION

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

In addition, the applicant's attention is drawn to the information contained in the Annex, relating to:

- [X] time limits for entry into the national phase
- [X] confirmation of precautionary designations
- [X] requirements regarding priority documents

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:

Y. KUWAHARA

Telephone No. (41-22) 338.83.38

INFORMATION ON TIME LIMITS FOR ENTERING THE NATIONAL PHASE

The applicant is reminded that the "national phase" must be entered before each of the designated Offices indicated in the Notification of Receipt of Record Copy (Form PCT/IB/301) by paying national fees and furnishing translations, as prescribed by the applicable national laws.

The time limit for performing these procedural acts is **20 MONTHS** from the priority date or, for those designated States which the applicant elects in a demand for international preliminary examination or in a later election, **30 MONTHS** from the priority date, provided that the election is made before the expiration of 19 months from the priority date. Some designated (or elected) Offices have fixed time limits which expire even later than 20 or 30 months from the priority date. In other Offices an extension of time or grace period, in some cases upon payment of an additional fee, is available.

In addition to these procedural acts, the applicant may also have to comply with other special requirements applicable in certain Offices. **It is the applicant's responsibility** to ensure that the necessary steps to enter the national phase are taken in a timely fashion. Most designated Offices do not issue reminders to applicants in connection with the entry into the national phase.

For detailed information about the procedural acts to be performed to enter the national phase before each designated Office, the applicable time limits and possible extensions of time or grace periods, and any other requirements, see the relevant Chapters of Volume II of the PCT Applicant's Guide. Information about the requirements for filing a demand for international preliminary examination is set out in Chapter IX of Volume I of the PCT Applicant's Guide.

GR and ES became bound by PCT Chapter II on 7 September 1996 and 6 September 1997, respectively, and may, therefore, be elected in a demand or a later election filed on or after 7 September 1996 and 6 September 1997, respectively, regardless of the filing date of the international application. (See second paragraph above.)

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

CONFIRMATION OF PRECAUTIONARY DESIGNATIONS

This notification lists only specific designations made under Rule 4.9(a) in the request. It is important to check that these designations are correct. Errors in designations can be corrected where precautionary designations have been made under Rule 4.9(b). The applicant is hereby reminded that any precautionary designations may be confirmed according to Rule 4.9(c) before the expiration of 15 months from the priority date. If it is not confirmed, it will automatically be regarded as withdrawn by the applicant. There will be no reminder and no invitation. Confirmation of a designation consists of the filing of a notice specifying the designated State concerned (with an indication of the kind of protection or treatment desired) and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.

REQUIREMENTS REGARDING PRIORITY DOCUMENTS

For applicants who have not yet complied with the requirements regarding priority documents, the following is recalled.

Where the priority of an earlier national, regional or international application is claimed, the applicant must submit a copy of the said earlier application, certified by the authority with which it was filed ("the priority document") to the receiving Office (which will transmit it to the International Bureau) or directly to the International Bureau, before the expiration of 16 months from the priority date, provided that any such priority document may still be submitted to the International Bureau before that date of international publication of the international application, in which case that document will be considered to have been received by the International Bureau on the last day of the 16-month time limit (Rule 17.1(a)).

Where the priority document is issued by the receiving Office, the applicant may, instead of submitting the priority document, request the receiving Office to prepare and transmit the priority document to the International Bureau. Such request must be made before the expiration of the 16-month time limit and may be subjected by the receiving Office to the payment of a fee (Rule 17.1(b)).

If the priority document concerned is not submitted to the International Bureau or if the request to the receiving Office to prepare and transmit the priority document has not been made (and the corresponding fee, if any, paid) within the applicable time limit indicated under the preceding paragraphs, any designated State may disregard the priority claim, provided that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity to furnish the priority document within a time limit which is reasonable under the circumstances.

Where several priorities are claimed, the priority date to be considered for the purposes of computing the 16-month time limit is the filing date of the earliest application whose priority is claimed.

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 32038-PCT

Box No. I TITLE OF INVENTION

SYSTEM AND METHOD FOR PERFORMING A PROGRESSIVE SECOND PRICE AUCTION TECHNIQUE

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK
Broadway and 116th Street
New York, NY 10027
US

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

SEMRET, NEMO
45 Tiemann Place, Apt. 5C
New York, NY 10027
US

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: CA

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

TANG, HENRY and
CUNNINGHAM, DAVID T.
Baker & Botts, LLP
30 Rockefeller Plaza
New York, NY 10112-0228
US

Telephone No. (212) 705-5000

Facsimile No. (212) 705-5020

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet is not to be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

LAZAR, AUREL
410 Riverside Drive
New York, NY 10027
US

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked):*

Regional Patent

☐ **AP ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☐ **EA Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☐ **EP European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☐ **OA OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line):*

☐ **AL** Albania .....
☐ **AM** Armenia .....
☐ **AT** Austria .....
☐ **AU** Australia .....
☐ **AZ** Azerbaijan
☐ **BA** Bosnia and Herzegovina .....
☐ **BB** Barbados
☐ **BG** Bulgaria .....
☐ **BR** Brazil .....
☐ **BY** Belarus
☒ **CA** Canada
☐ **CH and LI** Switzerland and Liechtenstein
☐ **CN** China .....
☐ **CU** Cuba .....
☐ **CZ** Czech Republic .....
☐ **DE** Germany .....
☐ **DK** Denmark .....
☐ **EE** Estonia .....
☐ **ES** Spain .....
☐ **FI** Finland .....
☐ **GB** United Kingdom
☐ **GE** Georgia .....
☐ **GH** Ghana .....
☐ **GM** Gambia
☐ **GW** Guinea-Bissau .....
☐ **HR** Croatia
☐ **HU** Hungary .....
☐ **ID** Indonesia
☐ **IL** Israel .....
☐ **IS** Iceland
☒ **JP** Japan .....
☐ **KE** Kenya .....
☐ **KG** Kyrgyzstan .....
☐ **KP** Democratic People's Republic of Korea .....
☐ **KR** Republic of Korea .....
☐ **KZ** Kazakhstan .....
☐ **LC** Saint Lucia
☐ **LK** Sri Lanka
☐ **LR** Liberia
☐ **LS** Lesotho .....
☐ **LT** Lithuania
☐ **LU** Luxembourg
☐ **LV** Latvia
☐ **MD** Republic of Moldova .....
☐ **MG** Madagascar .....
☐ **MK** The former Yugoslav Republic of Macedonia .....
☐ **MN** Mongolia
☐ **MW** Malawi .....
☐ **MX** Mexico .....
☐ **NO** Norway
☐ **NZ** New Zealand .....
☐ **PL** Poland .....
☐ **PT** Portugal .....
☐ **RO** Romania
☐ **RU** Russian Federation .....
☐ **SD** Sudan
☐ **SE** Sweden
☐ **SG** Singapore
☐ **SI** Slovenia .....
☐ **SK** Slovakia .....
☐ **SL** Sierra Leone
☐ **TJ** Tajikistan .....
☐ **TM** Turkmenistan .....
☐ **TR** Turkey .....
☐ **TT** Trinidad and Tobago .....
☐ **UA** Ukraine .....
☐ **UG** Uganda .....
☒ **US** United States of America .....
☐ **UZ** Uzbekistan .....
☐ **VN** Viet Nam .....
☐ **YU** Yugoslavia .....
☐ **ZW** Zimbabwe .....

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

☐ .....
☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CL ☐ Further priority clai[illegible]e indicated in the Supplemental Box.

Filing date of earlier application *(day/month/year)*	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1)				
item (2)				
item (3)				

☐ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): _____

** Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):*

ISA/ US

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date *(day/month/year)* Number Country (or regional Office)

Box No. VIII CHECK LIST: LANGUAGE OF FILING

This international application contains the following **number of sheets:**

request	:	4
description (excluding sequence listing part)	:	22
claims	:	6
abstract	:	1
drawings	:	10
sequence listing part of description	:	
Total number of sheets	:	43

This international application is **accompanied** by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as items(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☒ other *(specify):* Transmittal Letter

Figure of the drawings which should accompany the abstract:

Language of filing of the international application: English

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

David T. Cunningham (Agent)

For receiving Office use only

1. Date of actual receipt of the purported international application:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA/
6. ☐ Transmittal of search copy delayed until search fee is paid

2. Drawings:
☐ received:
☐ not received:

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

This sheet is not p[redacted] and does not count as a sheet of the internationa[redacted]ication.

PCT

FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International application No.

Date stamp of the receiving Office

Applicant's or agent's file reference: 32038-PCT

Applicant: THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE . . . . . 240.00 T

2. SEARCH FEE . . . . . 700.00 S

International search to be carried out by US

(If two or more International Searching Authorities are competent in relation to the international application, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

The international application contains 43 sheets.

first 30 sheets . . . . . 455.00 b_1

13 (remaining sheets) x $10.00 (additional amount) = 130.00 b_2

Add amounts entered at b_1 and b_2 and enter total at B . . 585.00 B

Designation Fees

The international application contains 3 designations.

3 (number of designation fees payable *(maximum 11)*) x 105.00 (amount of designation fee) = 315.00 D

Add amounts entered at B and D and enter total at I . . . . . 900.00 I

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled,

4. FEE FOR PRIORITY DOCUMENT *(if applicable)* . . . . . P

5. TOTAL FEES PAYABLE

Add amounts entered at T, S, I and P, and enter total in the TOTAL box: 1,840.00 TOTAL

☐ The designation fees are not paid at this time.

MODE OF PAYMENT

- ☐ authorization to charge deposit account (see below)
- ☒ cheque
- ☐ postal money order
- ☐ bank draft
- ☐ cash
- ☐ revenue stamps
- ☐ coupons
- ☐ other *(specify):*

DEPOSIT ACCOUNT AUTHORIZATION *(this mode of payment may not be available at all receiving Offices)*

The RO/ US

- ☐ is hereby authorized to charge the total fees indicated above to my deposit account.
- ☒ is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.
- ☐ is hereby authorized to charge the fee for preparation and transmittal of the priority document to the International Bureau of WIPO to my deposit account.

02-4377	23 March 1999	Dan Cumpa
Deposit Account Number	Date *(day/month/year)*	Signature

PATENT COOPERATION TREATY

99 JUN -1 PM 2:11

From the INTERNATIONAL SEARCHING AUTHORITY

To: HENRY TANG
BAKER & BOTTS, LLP
30 ROCKEFELLER PLAZA
NEW YORK, NY 10112-0228

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

	Date of Mailing *(day/month/year)* 26 MAY 1999
Applicant's or agent's file reference 32038-PCT	FOR FURTHER ACTION See paragraphs 1 and 4 below
International application No. PCT/US99/06384	International filing date *(day/month/year)* 23 MARCH 1999
Applicant THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK	

1. [X] The applicant is hereby notified that the international search report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the international search report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

DOCKETED
FOR 7/26/1999 BY

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in rules 90 *bis* 1 and 90 *bis* 3, respectively, before the completion of the technical preparations for international publication.

Within 19 months from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within 20 months from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer EMANUEL TODD VOELTZ
Facsimile N . (703) 305-3230	Telephone No. (703) 305-9714

Form PCT/ISA/220 (January 1994) *

(See notes on accompanying sheet)

* Rolleres in Pocket *

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 32038-PCT	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/US99/06384	International filing date *(day/month/year)* 23 MARCH 1999	(Earliest) Priority Date *(day/month/year)* NONE
Applicant THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (See Box I).

2. [ ] **Unity of invention is lacking** (See Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] transcribed by this Authority.

4. **With regard to the title,**
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established by this Authority to read as follows:

5. **With regard to the abstract,**
   - [ ] the text is approved as submitted by the applicant.
   - [X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. **The figure of the drawings** to be published with the abstract is:

   Figure No. 1
   - [ ] as suggested by the applicant.
   - [X] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.

   [ ] None f the figures.

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

The technical features mentioned in the abstract do not include a reference sign between parentheses (PCT Rule 8.1(d)).

A system and method for allocating a resource using a progressive second price auction technique. An auction is held for a limited resource, such as bandwidth in an Internet Service Provider Network in which bids are submitted by prospective users(103) including the quantity desired and the price for each unit of resource bid upon. In order to make an efficient allocation, a new bidder (105) is granted some of the resource based upon the availibility of the limited resource (109) due to the bids higher than the new bidder (113). The actual price paid (121) by the new bidder is based upon bids made with lower prices who have been or would have been allocated some of the resource. This calculation of the price paid encourages bidders to bid their actual valuation of the resources rather than engage in inefficient tactical bids.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/06384

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G06F 17/60
US CL :705/8, 37

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 705/7, 8, 37

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS (((negotiat? or bidd? or auction?) (5a) (bandwidth# or resource#)) and (internet or world()wide()web or www)), DIALOG (((second()price) (3n) (auction? or bidd?)) and next()high?)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FELDMAN, R.A., MEHRA, R. Auction: Theory and Applications. International Monetary Fund staff papers. September 1993, Vol. 40, No. 3, pages 485-511, especially pages 485-489.	1-42
A	ANONYMOUS, New Zealand Moves Toward Market Driven Spectrum Allocation. Spectrum Report, 01 February 1991, Vol. 1, No. 4, 1 page.	1-42
A	ANONYMOUS, Revenge of the Nerds: when government auctioneers need worldly advice, where can they turn ? To mathematical economists, of course. Economist, 23 July 1994, Vol. 332, No. 7873, page 70.	1-42
A	US 5,802,502 A (GELL et al.) 01 September 1998, see abstract.	1-42

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,640,569 A (MILLER et al) 17 June 1997, see abstract.	1-42
A	US 5,610,910 A (FOCSANEANU et al) 11 March 1997, see abstract.	1-42
A	US 5,487,168 A (GEINER et al) 23 January 1996, see abstract.	1-42

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(71) Applicant *(for all designated States except US)*: THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK [US/US]; Broadway and 116th Street, New York, NY 10027 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: SÉMRET, Nemo [CA/US]; Apartment 5C, 45 Tiemann Place, New York, NY 10027 (US). LAZAR, Aurel [US/US]; 410 Riverside Drive, New York, NY 10027 (US).

(74) Agents: TANG, Henry et al.; Baker & Botts, LLP, 30 Rockefeller Plaza, New York, NY 10112-0228 (US).

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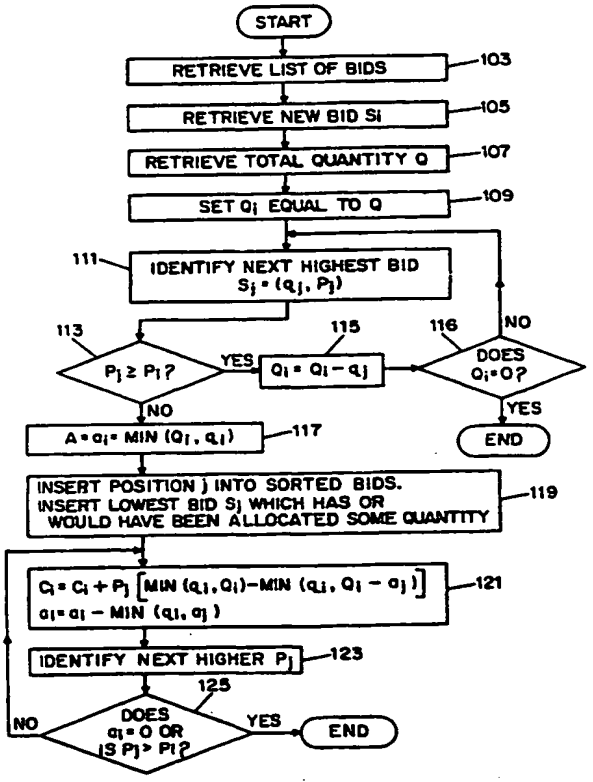
(57) Abstract

A system and method for allocating a resource using a progressive second price auction technique. An auction is held for a limited resource, such as bandwidth in an Internet Service Provider Network in which bids are submitted by prospective users (103) including the quantity desired and the price for each unit of resource bid upon. In order to make an efficient allocation, a new bidder (105) is granted some of the resource based upon the availability of the limited resource (109) due to the bids higher than the new bidder (113). The actual price paid (121) by the new bidder is based upon bids made with lower prices who have been or would have been allocated some of the resource. This calculation of the price paid encourages bidders to bid their actual valuation of the resources rather than engage in inefficient tactical bids.



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SYSTEM AND METHOD FOR PERFORMING A PROGRESSIVE SECOND PRICE AUCTION TECHNIQUE

SPECIFICATION

FIELD OF THE INVENTION

This invention relates to a system and method for performing a progressive second price auction technique in order to effectively allocate a finite resource among competing requestors.

BACKGROUND OF INVENTION

A significant problem is created when a finite divisible resource is desired by two or more entities and more of the resource is requested than can possibly be allocated and distributed to the requesting entities. When the demand for a resource or product exceeds the supply, market auctions can be created in order to properly allocate the limited resource or product to the requesting entities. For example, a finite commodity such as oil is only produced in limited quantities per month and the oil is auctioned and sold in international markets. If only one million barrels of oil is produced in a month, bidders can submit bids through the international market and typically the highest bidder will win its requested allocation of the oil and will pay the supplier of the oil the price which was bid.

The problem of allocating finite resources also occurs in the electronic world. The Internet allows parties to communicate and exchange data over vast distances. However, the rate of information flow can be affected by the number of users utilizing an Internet Service Provider ("ISP") and users are forced to endure long pauses in their network connections. If critical data needs to be transmitted and received almost instantaneously over a network, premium bandwidth of an ISP can be reserved for that user. While premium bandwidth can be provided by an ISP, the

bandwidth is a limited resource and many users will desire all or part of the available premium bandwidth. A standard auction of the bandwidth would consist of the premium bandwidth being allocated to the highest bidder for which the bidder pays the price of the bid. However, this type of auction produces inefficiencies for larger numbers of bidders and where the bids made and availability of the premium bandwidth change over time. Other allocation mechanisms require exchanging large messages to convey demand information and are inappropriate for communication networks due to the heavy signaling load they would impose. An improved auction and allocation technique is needed.

In order to achieve an improved allocation technique, some economic principles can be applied to the technique. The example of allocating the resource of premium bandwidth will be used in the following discussion. A communication network's value such as the Internet can be characterized by what economists call externalities. The principles of externalities are that the value a user gets from the network depends upon the valuation and behavior of the other users. One recognized principle is that a communication network is more valuable to a user if more people are connected to the network. A second recognized principle is that as the utilization of the network by one user increases, the quality of service obtained by the other users decreases. Resources are shared by users who because of distance, population size, or individual selfishness cannot or will not coordinate their actions sufficiently to achieve the most desirable allocation of resources. This externality principles model indicates that a game theoretic approach in which other bidders actions are determinative of allocations and costs to a bidder could be used to improve the allocation of resources on a communication network.

The allocation of limited resources in connection with a communications network can be performed in both an actual market embodiment, when users are bidding real dollars or other items of value, and a private system embodiment, where the bids are to performed with internal budget allocations in order to obtain limited resources of the processing entity. For example, different university departments could bid on time used on a special university component with university dollars supplied by the university.

In the emerging multiservice networks (ATM, Next-Generation Internet), neither flat pricing by the peak capacity of the user's connection as used in the current Internet nor time-of-day usage prices as used in the telephone system are viable solutions to gain an efficient allocation of resources. Thus there is a need to develop a new approach to pricing of network resources. The requirements of an efficient pricing system include: (1) sensitivity to the range of resource requirements (either through a sufficiently broad range of traffic classes which are priced differently or by allowing users to explicitly quantify resource requirements); (2) prices must be dynamically responsive to unpredictable demand (market based system); and (3) the pricing architecture should constrain as little as possible the efficiency trade-offs. It would be desirable to achieve an auction technique which meets the above requirements and provides a more efficient allocation of a finite resource.

SUMMARY OF THE INVENTION

The present invention is directed to a system and method for allocating a divisible resource using a progressive second price action technique. The technique retrieves data indicative of at least one previous bid comprising a quantity data component and a price data component, retrieves said data indicative of a new bid comprising a quantity component and a price component, allocates the resource to the first bids with price components higher than the new bid, allocates the resource to the new bid if there is some portion of the resource which has not yet been allocated and calculates the new bid's cost based upon the price component of the other bids which have been or would have been allocated the resource but for the new bid.

By calculating the cost of the resource based upon the principles of the progressive second price auction technique, which calculate the cost to the bidder response to other bidders, each bidder is encouraged to bid its true valuation for the resource and is discouraged from using inefficient bidding strategies. The use of the present technique leads to a more efficient allocation system. Additional new bidders can be processed and allocated resource and the cost of the allocation to the bidder will be based upon the other bids.

An example of a resource which can be allocated is premium bandwidth by an Internet Service Provider (ISP). The ISP can process bids from different clients requesting premium bandwidth using the second price auction technique. In one embodiment, the ISP performs an initial allocation based upon initials bids and processes each new bid after the initial allocation is done. In a second embodiment, no such initial allocation is required. The bids in an auction are sorted by price component, allocated resource for bids with price components above the new bid and then allocated resource for the new bid. The cost of the new bid is based upon the bids of lower bidders who would have been allocated some bandwidth if the new bid had not been made. Thus the cost to the bidder is based upon others bids. The cost charged to the new bid equals the sum of the quantity allocations reduced on other players weighted by the bid price of such players. This technique of calculated payments or other bids encourages people to bid their actual value for the resource because the cost paid by the winning bidder is based upon other bidders' bids.

The ISP can also make its own floor bid in order to make sure that bids awarded allocations will pay a certain cost level.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects, features and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying figures showing illustrative embodiments of the invention, in which

Fig. 1 is a flow chart of the steps describing the progressive second price auction technique;

Fig. 2 is a graphical example of an allocation of resources;

Fig. 3 is another graphical example of an allocation of resources;

Fig. 4 is a graph of a player's utility function for entering the auction as a function of possible bid prices and requested quantities;

Fig. 5 is a graphical example of an allocation of resources;

Fig. 6 shows three graphs indicating the affect of a new bidder on the allocation of a resource;

Fig. 7 shows three graphs indicating the affect of a new bidder in the auction;

Fig. 8 shows three graphs indicating the affect of another new bidder in the auction;

Fig. 9 shows a system of bidders and prices at the auction; and

Fig. 10 shows a diagram of a computer which could process the auction in accordance with the invention.

Throughout the figures, the same reference numerals and characters, unless otherwise stated, are used to denote like features, elements, components or portions of the illustrated embodiments. Moreover, while the subject invention will now be described in detail with reference to the figures, it is done so in connection with the illustrative embodiments. It is intended that changes and modifications can be made to the described embodiments without departing from the true scope and spirit of the subject invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

The inventive technique uses a progressive second price auction mechanism. A second price auction works as follows: if an object is being auctioned between the parties, the highest bidder will be awarded the object, however, the price the winning bidder pays is the second highest price bid. This type of bidding encourages bidders to bid their true valuation of the object making the auction efficient rather than attempting to engage in inefficient bidding tactics such as one dollar more than the expected highest bid. Since the highest bidder will be paying the cost of the second highest bid, there is no incentive to bid below the actual valuation of the object being bid upon. If all the other bidders are well below the bidder's bid, he will only pay the next highest bid. If the bidder bids above his valuation of the object, he may pay more than his valuation depending upon the other bidders which is not desirable. Thus there is no incentive to bid higher than valuation.

The progressive second price auction technique applications is extended from that of the single object example to cover bidding on divisible resources over time. The technique creates a very efficient mechanism to auction and

allocate a finite resource among multiple bidders. With many bidders in an auction, most players will receive a part of the resource commensurate with their valuation of the resource being auctioned.

Figure 1 is a flow chart of the steps for performing the progressive second price auction technique. While the technique described in Figure 1 can be used to auction any resource or other divisible good or service, the description will be of an auction of units of a generic resource. An application to an actual resources which can be allocated could be premium bandwidth for example. In Figure 1 and throughout this application, a bid is defined as having two components: a quantity component and a price component. For example, a bidder in an auction for a resource may submit a bid for five units (quantity) at a price of $2 per unit. While only quantity and price components of a bid are described in the preferred embodiment, additional components or other information could also be included in the bid as needed.

Step 103 retrieves a list of bids previously made for the resource in a particular auction which have been previously sorted by decreasing bid price. This means the bid with the highest price offered will be first in the list and so on. Alternatively, the bids can be sorted after they are retrieved. The list of bids can be stored in a computer file, in memory of the processor performing the auction, be inputted by the keyboard or transmitted over a network in real-time by the bidder's software bidding agreement at the time of the auction or can be retrieved by any other means when the progressive second price auction technique is performed. For example, if ten bidders have previously bid for premium bandwidth in an auction, these bids (including the quantity desired and price per unit offered) will be stored in the memory of a computer or other apparatus operating the technique. The bids will then be sorted by a conventional sorting technique to place the previous bids in order from highest and lowest. Alternatively, the bids can be stored in decreasing price order in a linked list as they are received. If the bid to be processed is the first bid made in the auction and no other bid have been stored, the bid will become the first bid in the list.

Step 105 retrieves the new bid (S_i) to be processed which has at least both a quantity component and price component. The quantity component is in predefined units for the auction, for example, one Mbps (Megabit per second) of bandwidth, and the price will preferably be in the form of price per unit. However, the price can also be entered in the form of total price for the quantity bid and the unit price can be easily calculated. Because the technique utilizes a second price auction technique, the new bidder will be encouraged to optimally submit a bid that is approximately the bidder's true valuation for the resource. The bidder optimally bids his true value because of the operation of the second price auction mechanism as explained above. The new bid can be submitted electronically over a network such as the Internet or can be entered manually into a computer performing the technique. For example, a new bidder desiring premium bandwidth may type in a bid of $4 per unit for three units of bandwidth into a computer and transmit the bid to the computer operating the technique over a network. A software agent can be programmed to automatically bid according to the user's needs and the market as represented by the other users' bids.

Step 107 retrieves a total quantity (Q) of resource which is being auctioned and which is available for use at one time. For example, if the resource being auctioned is premium bandwidth, the total premium bandwidth for a given ISP system or node may be 20 Mbps. Since there is only a finite amount of the premium bandwidth resource which can be used at one time, no amount of bandwidth over Q can be allocated. The quantity Q can be input manually or retrieved from electronic storage or be calculated by the auction processor. Additionally Q can be a predetermined value in the technique for the resource or can be calculated based upon other parameters. For example, if the resource being allocated is bandwidth, the ISP can monitor how much premium bandwidth is available to be auctioned with respect to the total bandwidth for a given time period. The ISP may increase the percentage of bandwidth which is designated premium. The value Q would then change over time due to the technical or market variables.

Step 109 initially sets the quantity remaining variable (Q_i) to equal the total quantity Q. At this point in the technique for processing the new bid, no

bandwidth has been allocated with respect to the new bidder according to the technique. The actual bandwidth can be utilized according to prior allocations at the time of the processing of the new bid. The quantity remaining variable Q_i indicates the amount of the resource which has not yet been allocated during the allocation technique for the new bid.

Step 111 identifies the next highest bid ($S_j=(Q_j,P_j)$) where S_j is the $_j^{th}$ bid; Q_j is the $_j^{th}$ quantity bid; and P_j is the $_j^{th}$ price bid. The first time the auction technique performs this step, the next highest bid identified will be the bid with the highest price included in the bid list. Since the bids have been sorted by decreasing bid price, the first bid in the list should initially be the highest. If the list is implemented as a linked list, a pointer will be pointing to the highest price bid.

Step 113 checks if the current identified bid in the list is greater than or equal to the new bid S_i in the auction. If the current identified bid in the list is greater than or equal to the new bid price, the technique continues with step 115. If the current bid pointed to in the list is less than the new bid price, than the technique continues with step 117.

Step 115 subtracts the quantity component of the current identified bid in the list from the value of the available quantity Q_i . Since the price of the current identified bid in the list is greater than the new bid, it will be awarded the quantity of resources that it had requested (to the extent the remaining quantity of resource is not yet assigned during this allocation for the new bid). The amount of the resource which has just been allocated to the higher bid in the bid list is subtracted from the available resource variable Q_i . If the new bid price is below previous bids from the bid list which in aggregate request a total allocation that equals or exceeds the available allocation of the service provider, the new bid will be allocated none of the resource because the resource has been allocated to the higher bidders. The new bidder will be forced to increase its bid price in a subsequent bid or obtain the resource from another source. If the current identified bid in the list of retrieved bids requests more resource than is currently available as identified in Q_i, the entity making the bid will be allocated the remaining portion of the resource. In that case, the new bidder will receive some of the resource that was requested.

Step 116 checks if the quantity remaining variable Q_i is equal to zero. If it is equal to zero, then there is no more resource to be allocated to the new bidder S_i and the technique is completed for the new bidder S_i with respect to the bid made. The bidder may then increase its bid price and submit a new bid. If Q_i does not equal zero, then the testing of received bids in the list continues and the technique goes to step 111.

Step 117 is reached if the bid price in the new bid S_i is high enough such that some amount of quantity remains to be allocated at that bid price. For example, if the total allocation was 9 units and the auction computer has previously received bids (quantity, price) of (3, $7), (3, $6), (3, $2), and the current bid S_j is (3, $5), the first two bids of $7 and $6 would each be allocated 3 units and 3 units would remain to be allocated ($Q_i = 3$). Step 117 then allocates the proper amount of the resource to the new bidder S_j by taking the minimum of (1) Q_i (the amount remaining) and (2) q_i (the amount of requested). Thus, the new bid S_i will be assigned the quantity requested to the extent it is available and not already assigned. In the example above, the new bidder would be assigned 3 units.

Steps 119 through 123 calculate the price for the new bidder according to the progressive second price auction technique. Step 119 places the new bid in sorted order into the list of bids. For example, the bid could be added to a linked list such that the bid prices are arranged in descending order. The lowest bid which has previously received an allocation of the resource is then identified. If an initial allocation has not yet been performed, then the lowest bid is identified which would have been allocated some of the resource if the new bid was not present.

Step 121 then calculates the total cost for the new bidder based upon the progressive second price auction technique. The cost is calculated on an exclusion compensation principle: the new bidder i pays for his allocation so as to cover the "social opportunity cost" which is given by the declared willingness to pay (through their bids) of the users which are excluded by i's presence. The operator and supplier of resources at the auction is thus compensated for the maximum lost potential revenue from the new allocation.

Thus in the previous example, if the lowest bid receiving an allocation

of resources was $2 for three units before the new bid, these three units would be reassigned to the new bidder who just bid $5 for the three units. The new bidder S_j would then be charged $2 for each unit allocated.

If an additional bidder now entered the bidding with a bid of (3, $5.50), the stored bidding list would include the following: (3, $7), (3, $6), (3, $5), (3, $2) with the first three bids being allocated three units each. The new bidder at $5.50 would be allocated the three units of the $5 bidder at a cost of $5 per unit according to the second price auction rule. Thus allocation prices are always based upon the bids of the bidder with lower bids who had previously received an allocation or would have received an allocation but for the new bidder.

Step 121 shows how the cost for a new bidder who is receiving an allocation of the resource is calculated. For each bid with a lower bid price which received an allocation of the resource before the new bid, the bid price is added to the total cost charged to the new bidder until the allocated quantity matches the requested quantity in the bid. This reflects the shift in allocation from the lower bidders to the new bidder with the higher bid. The amount reallocated for each previous bid is responsive to how much quantity was previously allocated or would have been at that bid level. Thus the cost C_i is equal to C_i plus the price of the unit bid times the minimum of (1) the quantity being reallocated and (2) quantity allocated for the previous bid. If an allocation of 2 units at $3 is reallocated during the processing of a new bid of 4 units at $4, 2 units will be reallocated for that new bid from the lower bid. The quantities allocated in the next higher bids (but below the new bid price) will then be used to further calculate the total cost of the new bid reflecting the displaced allocation.

After the reallocation has been performed for a particular bid, the amount to be reallocated for the new bid is reduced by the minimum of (1) the amount to be reallocated a_i and (2) the amount allocated at the retrieved bid Q_i ($a_i=a_i-m_w(j, a_i)$). Thus once the allocation amount requested in the bid has been accounted for by one or more lower bids which have been or would have been allocated, no further costs need to be taken into account.

Step 123 then identifies the next higher P_j to be used in calculating C_j. The process then continues with step 125. Step 125 checks if a_i (the amount remaining be reallocated) is zero or if a P_j exists which is greater than P_i. If one of these conditions is true, then the process is complete for the new bid. If there are additional lower P_j to process and there is some resource which is to be reallocated, the process P_j continues with step 121.

Figures 2 and 3 are graphical examples of the change in an allocation of resources in response to a new bid being processed. Figure 2 depicts an allocation of resources based upon previous bids before the new bidder has entered the auction a new bid is processed. In this example, the total quantity of resources (Q_T) is thirty-five units as indicated in box 203. In this example, the following bids are retrieved as indicated in box 205: the first retrieved bid S_1 is for 7 units at \$1 per unit; the second retrieved bid S_2 is for 18 units at \$2 per unit; the third retrieved bid S_3 is for 5 units at \$3 per unit and the fourth retrieved bid S_4 is for 10 units at \$10 per unit. Graph 201 shows a horizontal axis indicating bid quantity 207 and a vertical axis indicating bid price 209. The bids located to the right of the vertical axis are allocated a portion of the resource being auctioned. The bids are initially allocated according to the highest bid price. Thus the fourth bid S_4 (the highest bid price) is indicated by bar 211. Bar 211 shows that the entire 10 units requested by the bid have been allocated. Bar 213 shows the allocation for the third bid S_3 which received all of its five requested units. Bar 215 shows the allocation for the second bid S_2 which received all of its 18 requested units. After the bids S_4, S_3 and S_2 were allocated, only two units remained unallocated (35-10-5-18 = 2). Thus, bar 217 indicates two units being allocated to bid S_1 and five units requested by S_1 not receiving an allocation (shown to the left of the vertical axis). The price levels on the graph indicate the bid price and the not price actually paid. The cost of the successful bid is calculated using the progressive second price auction technique described in connection with Figure 1.

Figure 3 shows a graphical example of how the allocation changes if a new fifth bid comes into the auction as S_5 (5, \$2.50) according to the present technique. Figure 3 shows the graph 201 but now with the new allocation due to the processing of the new bid S_5. Graph 301 has a horizontal axis indicating bid quantity

307 and a vertical access indicating the bid price 309. The total level of quantity available is still 35 units as indicated in box 203. The new bid S_5 is shown in the bid list 305 and is placed in the order of prices bid. Bid S_5 with a bid price of $2.50 is shown between S_2 and S_3. The graph now reflects the allocation to each bid after the new bid is taken into account.

In Figure 3, the entity with bid S_4 is again allocated 10 units as shown by bar 311. The person with bid S_3 is again allocated 5 units as shown by bar 313. The next highest bid is S_5 so the bidder of S_5 is allocated the five units requested. Between S_4, S_3 and S_5, twenty units have been allocated thus only 15 units remain (35-10-5 = 15). The next highest bid, S_2, has requested an allocation of 18 units. However, since only 15 units remain to be allocated, S_2 receives 15 bars as shown by bar 315. This is three less than is shown in Fig. 2. Bid number one who requested seven units is now allocated zero units as shown by bar 317 which is to the left of the vertical axis.

The cost of the new allocation to new bidder S_5 is the amount displaced 321 by the reallocation. Thus the total cost for the five units reallocated and displaced by the bid S_5 is (3 units x $2) + (2 units x $1) = $8. The unit cost for the fifth bidder S_5 is the total cost divided by the number of units allocated or 8/5 = $1.6. Thus bidder five will pay $1.6 per unit even though he bid $2.5 per unit according to the progressive second price auction technique.

Because the allocation and actual price paid are based upon other bids for the resource, the auctioneer can submit its own floor bid to buy the resource at a particular price. This will stop initial bidders from acquiring the resources for too low a price and will allow the auctioneer to influence the price paid by others. The floor price must be set at an appropriate level or the auctioneer may not sell the resources to other bidders at all.

The progressive second price auction technique meets the requirements of an efficient pricing system by allowing for varying bids by the bidding entity and allowing a bidder to specify the quantity requested, having resource prices which are responsive to the market conditions and limiting restraints on efficiency.

In order to make efficient bids in an auction that is being carried out on a continuous and quick manner such as auctioning bandwidth, a valuation technique can be used to quickly enter the bids of a bidder into an electronic auction to get an efficient result. Each player i has a valuation of the resource $\Theta_i(a_i(s)) \geq 0$ which is the total value of the allocation received. A bid profile can be created to get a utility $U_i(s)$ where $U_i(s) = \Theta_i(a_i(s)) - C_i(s)$ which is the value minus the cost. Additionally, bidders can have a budget constraint of the total cost which can be spent for a resource for a period of time so that the total cost of the bids must be under the budget parameter b.

Figure 4 shows a graph 401 of a player's utility function for entering the auction at a particular bid price. In the auction in this example, there are five other bidders with the following bids: $S_1 = (100, 1)$; $S_2 = (10, 2)$; $S_3 = (20, 4)$; $S_4 = (20, 7)$ and $S_5 = (30, 12)$. The new player S_6 has a valuation function of $\Theta_6(q) = 10q$ (or \$10 per unit). The plateaus at the top of the graph 401 show where the quantity requested by the new bidder can no longer be increased at that bid price because they have been allocated to other bidders. Graph 401 has three axis: quantity 403, price bid 405 and utility 407. While the new bid price is under ten, the utility is increasing as shown in the figure. However, if the price of the new bid has a price component over 12 in order to get additional quantity, the overall utility for each extra unit decreases because the most the bidder is willing to pay for an allocation of resources is ten dollars per unit. The utility graph can be shown in another form as in Figure 5.

Figure 5 shows an allocation graph similar to the graphs shown in Figures 2 and 3. Box 501 shows the valuator function 10q (or ten times the quantity) where the quantity is shown on the horizontal axis and utility is shown in the vertical axis. In the graph 503, the bids discussed in the example of figure 4 are shown. The horizontal axis indicates quantity allocated 505 and the vertical axis is the price of the bid 507. The total quantity to be allocated is one hundred units. The bids for the auction are indicated in box 509. The allocation to bid S_1 is indicated by bar 511; the allocation to bid S_2 is indicated by bar 513; the allocation to bid S_3 is indicated by bar 515; the allocation to bid S_4 is indicated by bar 517 and the bid S_5 is indicated by bar 519. Bid S_5 is only allocated twenty units of all of the overall units. In order to

determine the optimal bid by a new play S_6 with a valuation function shown in box 501. the derivative of the valuation function is taken to determine the slope of the demand. The derivative of the new bidder's valuation function is shown in graph 503 as line 521. Every quantity indicated in a bar below line 521 is more valuable to the new bidder than those quantities bid by other bidders with lower price components. Thus the new bidders would want to bid $10 in order to obtain seventy of the total units which includes the twenty units of line 513, the twenty units of line 515, ten units of line 517 and twenty units of line 519. Additional units could cost above the calculation for the unit so a higher bid would not be efficient. The actual cost which the new bidder will pay is calculated using the technique described in connection with Figure 1. The thirty units shown by bar 511 were bid at a price of $12 which is above the price of $10, the utility derived by the new bidder. Thus the new bidder would obtain 70 units at a bid price of $10. While a straight line derivative function is shown in the example, more complicated valuation functions can be used to model the correct bidding strategy.

Auctions, as formulated here, are applicable in a setting where the resources are arbitrarily divisible. Thus, this approach would fit well in a system where arbitrary amounts of resources can be requested and obtained, such as in pricing of the "expected capacity" profiles in the Internet with differential service.

For network resource allocation which is time based, bidding could be for example on a per flow basis or per unit time on an appropriate time scale. A flow level model can be used particularly if the entity in the auction is a software bidding agent, possibly embedded into a software application, which develops (over time and with human feedback) an accurate estimate of the entity's utility function Θ, the relationship between resources and value or perceived level of service.

An example of a flow level auction includes an agent-based system implemented in a common programming language and a seller which is an ISP whose network has a bottleneck bandwidth (maximum resource capacity) of 45 Mbps. The example described is an actual auction performed using the progressive second price auction mechanism. Using a flow level service model, the ISP allocates capacity to all its users. In that service model, the allocation is a traffic profile for each user.

enforced by a profile meter at the point of connection to the network. The network offers premium service to all in-profile packets (e.g. lower loss and/or delay) and any out-of-profile traffic gets best-effort service. The provider must provision the network to carry all the in-profile traffic that it expects at a given time, or conversely, must not sell more capacity ("sum" of profiles) than it has in the worst case scenario. Depending on how strictly the ISP wants to honor the contract and how well it can predict the routes it expects the traffic to take, it will sell a total capacity which is equal or greater than the bottleneck capacity. In this example it is assumed the ISP is extremely conservative, so it will only sell 45 Mbps so that all units sold will be supplied. In addition the ISP must ensure that it in turn purchases a large enough profile from neighboring networks to ensure that the in-profile traffic of its users get the contracted service even after it leaves its network. The reserve price p_0 corresponds to the price paid by the network to get capacity from neighboring networks.

The profiles for the bidders in this example can be any traffic descriptor. For example, the allocation can give the users a minimum guaranteed bandwidth (which will be the allocated quantity), with each user being allowed to burst up to their physical line rate. This can be done for example with a "leaky-bucket" traffic meter. If the bucket sizes are fixed by the ISP, and users are allocated (and pay for) a token rate. The bucket size determines the maximum in-profile burst size, and would correspond to the worst case buffer occupancy -- or delay -- that the ISP can tolerate for premium traffic. Clearly the quality of service for most internet traffic will be better if the allocated premium bandwidth is increased. But, because the profile allows for bursts, the improvement in quality will decrease as the premium bandwidth approaches the physical line rate, and of course, there is no use in having a premium bandwidth greater than the peak rate. Therefore, a reasonable model of a bidder's valuation is strictly increasing and concave up to the peak rate, and flat above the peak rate ("Bidding Valuation Curve").

To represent a realistic range of the connection speeds of users who would request premium bandwidth from home or small business users to a peer network connecting with a T3 line, the user population in this example has line rates q_i

ϵ {256 Kb/s, 1.5 Mbps, 45 Mbps}. ISPs currently charge T1 connections at flat rates of $500-$1500 per month. This works out to $0.008-$0.023 per Mbps per minute. Similarly, dial-up users are charged flat-rates of $10-$30 per month for 30 Kbps connections, which works out to $0.007-$0.021 per Mbps per minute. The closeness between the two cases indicates that these flat rates are rough indications of average valuations. The operator of the auction can also charge a small amount to process each bid.

The following bidding technique can be used as a strategy by an entity bidding in the progressive second price auction: if the utility for the bidder is increased by increasing the bid price or quantity requested and still remain within budget, submit a new bid with increased price and/or quantities.

The order of the bids is inconsequential for the bidding technique. Bidders join the auction at different times and bid, for example, once per second. This, along with communication delays which make the times at which bids arrive at the server and updates at the clients essentially random times, make the distributed auction asynchronous.

The above described bidding technique can be described as selfish and short-sighted. It is selfish because it will submit a new bid if and only if it can improve its own utility (by more than the fee for the bid) and short-sighted because it does not take the extensive form of the auction into account, i.e., does not use strategies which may result in a temporary decrease but a better utility in the long run by tactically exploiting other users.

In this example, the total capacity is $Q = 45$ Mbps. A bid fee is the fee paid to the operator of the auction to make the bid. It is typically a relatively small amount relative to the bid price. The bid fee in this example is ϵ = $0.00125. All times for the example are in seconds. In this example, the auction is run with one agent (bidding computer) per user, and the agents are distributed evenly on different workstations. The auctioneer agent (processing computer) runs alone on a separate workstation such as a Sun Ultra-2 SPARC workstation. "Arrivals" of new players correspond to Internet users whose profile was zero (pure best-effort) who have not been bidding who suddenly request a bidding profile. This could be for example users

who are content with best effort traffic at night and on weekends, but require better bandwidth during business hours.

In this example, we begin at $t_0 < 0$ with a population consisting of:

(1) 20 users (bidders 1-20) with a peak rate of 1.5 Mbps

(2) 2 users (bidders 21 and 22) with a peak rate of 45 Mbps

(3) 50 users (bidders 23-72) with a peak rate of 256 Kb/s

The valuations for each player follow the Bidder Valuation Curve, as described above. We let this set of users bid according to their valuations until an equilibrium is reached (i.e., no new bids have been received for a few minutes), at some time $t < 0$. We then show the affect of new players with bids entering and leaving the auction as shown in Figure 6.

Figure 6 shows three graphs showing the affect of the new small user on the auction. Graph 601 shows the requested quantity of bandwidth allocation for the 256 Kb/s line rate user. The horizontal axis for graph 601 is time and the vertical axis is bandwidth request. Graph 603 shows the allocation for the new bidder. The horizontal axis for graph 603 is time and the vertical axis is bandwidth allocated. Graph 605 shows the bid and paid price for the bandwidth. The horizontal axis for graph 605 is time and the vertical axis is dollars per (minutes X Mbps). The bid price is indicated by the solid line and the paid price is indicated by the dotted line. The paid price (cost) line is lower than the bid price because of the progressive second price auction process being used. The bid price and paid price are close to one another because of the relatively large number of bidders in the auction.

Figure 7 shows three graphs showing the affect of the new small user on the auction from a different perspective. Graph 701 shows the requested quantity of bandwidth allocation for the 1.5 Mbps line rate user. The horizontal axis of graph 701 is time and the vertical axis is bandwidth request. Graph 703 shows the actual allocation for the new bidder. The horizontal axis of graph 703 is time and the vertical axis is bandwidth allocated. Graph 705 shows the bid and paid price for the bandwidth. The horizontal axis of graph 705 is time and the vertical axis is dollars per (minutes X Mbps). The bid price is indicated by the solid line and the paid price is indicated by the dotted line. The paid price (cost) line is lower than the bid price

because of the progressive second price auction process being used. The bid price and paid price are close to one another because of the relatively large number of bidders in the auction.

Figure 8 shows three graphs showing the affect of the new small user on the auction from a different perspective. Graph 801 shows the requested quantity of bandwidth allocation for the 45 Mbps line rate user. The horizontal axis of graph 801 is time and the vertical axis is bandwidth request. Graph 803 shows the actual allocation for the new bidder. The horizontal axis of graph 803 is time and the vertical axis is bandwidth allocated. Graph 805 shows the bid and paid price for the bandwidth. The horizontal axis of graph 805 is time and the vertical axis is dollars per (minutes X Mbps). The bid price is indicated by the solid line and the paid price is indicated by the dotted line. The paid price (cost) line is lower than the bid price because of the progressive second price auction process being used. The bid price and paid price are close to one another because of the relatively large number of bidders in the auction.

The following events in this example are reflected by the changing allocations to the different bidders as shown in Figures 6, 7 and 8:

(1) At $t = 0$, player 73 (a new 256 Kb/s user) joins. Initially, the new user assumes the market is empty, so he asks for a large profile. As his knowledge of the opponent profile is updated (received by the processor of the auction), he realizes this is too expensive, decreases his quantity, and raises the bid-price. Figure 6 shows that after three bids by the new player (and reactions by others), the market has stabilized at a new equilibrium by $t = 170$, where player 73 has an allocation of a premium bandwidth $a_{73} = 128$ Kb/s.

(2) At $t = 550$, player 74 (a new 1.5 Mbps user) joins. Figure 7 shows that after two bids by player 74, by $t = 600$, a new equilibrium is reached with $a_{74} = 728$ Kb/s. At this new equilibrium, the unit price paid by player 73 is increased slightly from 0.00625 to 0.00629 (barely visible on Figure 6).

(3) At $t = 890$, player 75 (a new 45 Mbps user) joins. Unlike the previous

two, this large arrival has a significant impact on the market. Figure 8 shows that by t = 1200, after 28 bids by the new player, a new equilibrium is reached, where a_{75} = 19 Mbps. At the new equilibrium, player 74's share of the premium bandwidth drops from 728 Kb/s to 540 Kb/s, and the price paid per unit to rises from 0.0063 to 0.008.

(4) Between time t = 1600 and 1700, 50 new users with peak rates of 256 Kb/s join the game. This causes the market to fluctuate for a few minutes, and a new equilibrium is reached where the prices are slightly higher, and allocations slightly lower for the existing players (see Figures 6 to Figures 8).

(5) Just before t = 2500, players 1-20 (all 1.5 Mbps line rate) suddenly leave. This causes a sharp drop in the market, which takes about 200 seconds to stabilize. The subsequent equilibrium is not much different from the previous one, in terms of both allocations and prices, despite the fact that potential demand has been reduced by about 30 Mbps. This is because many users with lower valuations who were not fully satisfied before now use up the freed capacity, and there is still enough unsatisfied demand just below the market clearing price to keep prices at almost the same level.

(6) At t = 3140, players 21-22 (both 45 Mbps rate) suddenly depart. The freed capacity is enough to satisfy a lot of pent-up demand, so the prices drop by about half, to around $0.004, and allocations increase for the remaining players.

Note that throughout this example, of the three players described, the T3 user (player 75) pays a lower price per unit than the other two. This "volume discount" occurs because of the greater bandwidth allocation to player 75 and the fact that in the progressive second price auction mechanism more lower price bidders are being displaced by the higher quantity requested.

These examples show that the impact of many small independent users is much smaller on the market dynamics than that of a single user with the same total demand. For each small user, his inability to "move" the market with his bid makes it

in effect equivalent to a retail market. This suggests that for the smallest users, the market can be approximated by simply advertised prices (which arise from the interaction among medium and large users), and the user making a simple choice of whether to buy or not. This is indeed what occurs with most commodities (e.g., oil).

The progressive second price auction generalizes key properties of traditional single non-divisible object auctions to the case where an arbitrarily divisible resource is to be shared. The allocation technique assuming an elastic-demand model of user preferences constitutes a stable and efficient allocation and pricing mechanism in a network context, both for Virtual Path/Virtual Network and edge capacity pricing applications.

Figure 9 is a diagram of an example of a system which can use the progressive second price auction technique. System 901 includes Internet Service Providers ISP1 903, ISP2 905 and ISP3 907. Each Internet Service Provider is connected to a network. ISP1 903 is connected to network 909, ISP2 905 is connected to network 911 and ISP2 907 is connected to network 913. Bidding entities 915 are computers which are connected to a network (either network 903, 905 and 907) and participate in auctions by sending electronic bids including a quantity request component and a bid price component to the ISP to which they are connected. The bids can be individual bids or in the form of a valuation data expressed by multiple price component and quantity component bids or a valuation function expression. The bidding entities 915 include a central processing unit and memory which stores a set of instructions for formulating and transmitting the bids to the auction processor (in this example the ISP). An ISP can also transmit auction updates to the bidding entities 915. System 901 can be used to auction premium bandwidth by an ISP.

The Internet is made up of a number of networks connected together such that a message will eventually be transmitted from a sending party to a receiving party. Thus if a bidder is bidding on premium bandwidth, a message will typically need to travel over numerous networks to reach its destination. Thus the premium bandwidth must be allocated by each network and the bids required to secure the overall connection contribute to the complete cost.

For the purpose of this auction example, each ISP is requested by a computer which includes a processor and memory and is described in more detail in the description of Figure 10. If a bidding entity wants to transmit information to an entity that is not directly connected to the transmitting entity's ISP, the ISP needs to secure their proper bandwidth from the intervening and destination ISP. This is accomplished by the ISP becoming a bidding entity itself (as shown by box 904) where the ISP bids for another's ISP bandwidth in order to ensure that the data flow bandwidth will be allocated for the entire connection, not just through the ISP's connections. Thus ISP 903 will act as a bidding entity 904 for the auctions performed by ISP2 905 and ISP3 907 if the bandwidth from those ISPs is required by the bidders in ISP's auction. An alternative arrangement is to have the bidder place bids himself in each of the ISP auctions. However, this leads to inefficiencies if the network path includes many ISPs who must allocate the bandwidth for the data exchange and the bidder is only connected to one ISP.

New bidding entity 917 is a bidder who has just entered the auction preferably after a number of other bids have been submitted. However, the new bidder 917 can also be the first entity to enter the auction. In the latter case there is preferably a floor bid which is provided by the ISP which is operating the auction.

Figure 10 is a diagram of an Internet Service Provider. The ISP network bandwidth is controlled by a computer which preferable includes a central processing unit 1001, a memory 1003 connected to the CPU 1001, an input/output (I/O) port 1005 and a databus 1007 connecting processor 1001, memory 1003 and I/O port 1005. In the example of allocating premium bandwidth, the ISP preferably operates the progressive second price auction technique. Program instructions implementing the progressive second price auction technique are stored in memory 1003 which are executed by processor 1001 to perform the technique as described in connection with Figure 1. As the ISP receives bids for an auction, the bids can be stored in memory 1003. Alternatively, the bids can be stored in a memory outside of the ISP but which is accessible to the ISP. I/O port 1005 is connected to one or more networks which the Internet Service Provider manages.

Memory 1003 also can store data related to the allocation process such as the maximum amount of the resource which can be allocated, the present allocation of the resource and the past history of the allocation and payments made to the ISP after the bids have been accepted. Processor 1001 can perform the calculation necessary to perform the allocations and calculate the costs of a new bidder using the progressive second price auction technique.

The foregoing merely illustrates the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise numerous systems and methods which, although not explicitly shown or described herein, embody the principles of the invention and are thus within the spirit and scope of the invention.

For example even though this application describes solving problems of bandwidth and buffer space reservation in a communication network, the auction technique is formulated in a manner which is generic enough for use in a wide range of situations.

CLAIMS

1. A method of allocating a resource comprising the steps of:

retrieving data indicative of at least one bid comprising a quantity data component and a price data component;

retrieving second data indicative of a new bid comprising a quantity component and a price component;

first allocating said resource to said at least one bid with a price component higher than the price component of said new bid;

allocating said resource to said new bid responsive to said first allocation step;

calculating said new bid's cost responsive to said price component of at least one bid with a price component lower than said price component of said new bid; and

storing cost data indicative of said calculated cost.

2. The method of claim 1, wherein said resource is bandwidth.

3. The method of claim 1, wherein said new bid's resource allocation and said calculated cost are transmitted to an entity who made said new bid.

4. The method of claim 1, wherein said allocated resource is utilized by an entity associated with said bid.

5. The method of claim 1, further comprising a step ordering said retrieved at least one bid by said at least one bid's price component.

6. The method of claim 1, further comprising the step of retrieving data indicative of said resource's maximum capacity and wherein said allocation steps are responsive to said maximum capacity.

7. The method of claim 6, wherein said resource is allocated to said new bid only if said first allocation in less than said maximum capacity.

8. The method of claim 1, wherein an initial allocation of said resource is performed before said new bid is processed.

9. The method of claim 8, wherein said calculating said new bid's cost is responsive to at least said retrieved bid with data indicative of said lowest price component which has been allocated in said initial allocation.

10. The method of claim 8, wherein said calculating said new bid's cost is responsive to a plurality of said retrieved bids with data indicating said prices which are lower than said new bid.

11. The method of claim 1, wherein said calculating said new bid's cost is responsive to at least said retrieved bid with data indicative of said lowest price which would have received an allocation if said new bid was not retrieved.

12. The method of claim 11, wherein said calculating said new bid's cost is responsive to a plurality of said received bids with data indicative of prices lower than said new bid.

13. The method of claim 1, wherein one of said at least one bid is submitted by a processor performing said allocation steps.

14. The method of claim 1, wherein said at least one bid comprises valuation data comprising a plurality of price components associated with a plurality of quantity components.

15. The method of claim 14, wherein said allocation is responsive to said plurality of price components and said quantities components.

16. The method of claim 1, wherein said new bid comprises valuation data comprising a plurality of price component associated with a plurality of quantity components.

17. The method of claim 16, wherein said allocation is responsive to said new bid's plurality of price components and said quantity components.

18. An apparatus for allocating a resource comprising:

means for retrieving at least one bid comprising a quantity component and a price component;

means for retrieving a new bid comprising a quantity component and a price component;

means for first allocating said resource to said at least one bid with a price component higher than said new bid;

means for allocating said resource to said new bid responsive to said first allocation step; and

means for calculating said new's bids cost responsive to said price component of at least one bid with a price lower than said new bid.

19. The apparatus of claim 18, wherein said resource is bandwidth.

20. The apparatus of claim 19, further including means for storing data indicative of said cost.

21. The apparatus of claim 18, further comprising means for ordering said retrieved at least one first bid by said bid's price component.

22. The apparatus of claim 18, further comprising means for retrieving said resource's maximum capacity and allocating said resource responsive to said maximum capacity.

23. The apparatus of claim 22, wherein said resource is allocated to said new bid by said allocation means only if said first allocation in less than said maximum capacity.

24. The apparatus of claim 18, wherein an initial said allocation of said resource is completed by said first allocation means before said new bid is processed.

25. The apparatus of claim 24, wherein said calculating said second bid's cost by said allocation means is responsive to at least said retrieved bid with said lowest price which has been allocated in said initial allocation.

26. The apparatus of claim 25, wherein said calculating said new bid's cost by said allocation means is responsive to a plurality of said received bids with prices lower than said new bid.

27. The apparatus of claim 18, wherein said calculating said new bid's cost by said allocation means is responsive to at least said retrieved bid with said lowest price which would have received an allocation if said new bid was not made.

28. The apparatus of claim 27, wherein said calculating said new bid's cost by said allocation means is responsive to a plurality of said received bids with prices lower than said new bid.

29. The apparatus of claim 18, wherein one of said at least bids is submitted by an operator of said apparatus.

30. The apparatus of claim 18, wherein said at least one bid comprises valuation data comprising a plurality of price component associated with a plurality of quantity components.

31. The apparatus of claim 30, wherein said allocation by said allocation means is responsive to said plurality of price components and said quantities components.

32. The apparatus of claim 18, wherein said new bid comprises valuation data comprising a plurality of price component associated with a plurality of quantity components.

33. The apparatus of claim 32, wherein said allocation by said allocation means is responsive to said new bid's plurality of price components and said quantity components.

34. A system for allocating a resource comprising:

at least one bidding entity for providing bids comprising a quantity component and a price component;

a new bidding entity for providing at least one bid comprising a quantity component and a price component; and

A processor for first allocating said resource to said at least one bid with a price component higher than the second bid and for allocating said resource to said new bid responsive to said first allocation step; wherein said processor calculates said new's bids cost responsive to said price component of at least one bid with a price lower than said new bid.

35. The system of claim 34, wherein said resource is bandwidth.

36. The system of claim 34, wherein said processor transmits information indicative of said price component of said new bidding entity to said at least one bidding entity.

37. The system of claim 34, wherein said processor retrieves data indicative of said resource's maximum capacity and allocates said resource responsive to said maximum capacity and wherein said resource is allocated to said new bid only if said first allocation in less than said maximum capacity.

38. The system of claim 34, wherein said calculating said new bid's cost is responsive to at least said retrieved bid with said lowest price component which has been allocated in said initial allocation.

39. The system of claim 34, wherein said calculating said new bid's cost is responsive to a plurality of said received bids with prices lower than said new bid.

40. The system of claim 34, wherein said calculating said new bid's cost is responsive to at least said retrieved bid with said lowest price which would have received an allocation if said new bid was not made.

41. The system of claim 34, wherein said at least one bid comprises a plurality of price component associated with a plurality of quantity components.

42. The system of claim 41, wherein said allocation is responsive to said plurality of price components and said quantity component.

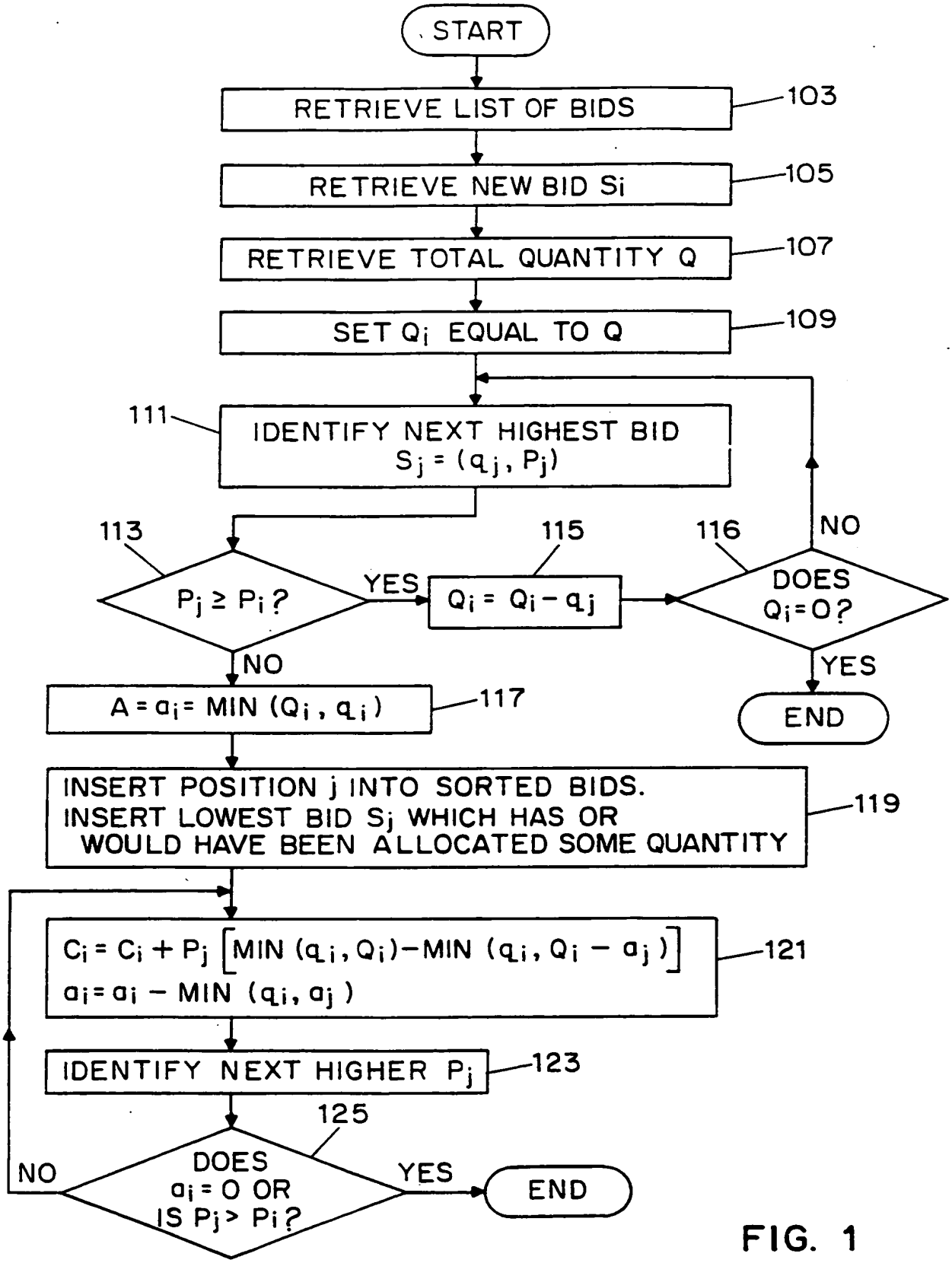
START
RETRIEVE LIST OF BIDS
103
RETRIEVE NEW BID Si
105
RETRIEVE TOTAL QUANTITY Q
107
SET Qi EQUAL TO Q
109
111
IDENTIFY NEXT HIGHEST BID
Sj = (qj, Pj)
113
Pj ≥ Pi ?
YES
115
Qi = Qi − qj
116
DOES
Qi=0?
NO
YES
NO
A = ai = MIN (Qi, qi)
117
END
INSERT POSITION j INTO SORTED BIDS.
INSERT LOWEST BID Sj WHICH HAS OR
WOULD HAVE BEEN ALLOCATED SOME QUANTITY
119
Ci = Ci + Pj [MIN (qi, Qi)−MIN (qi, Qi − aj)]
ai = ai − MIN (qi, aj)
121
IDENTIFY NEXT HIGHER Pj
123
125
DOES
ai = 0 OR
IS Pj > Pi?
NO
YES
END

FIG. 1

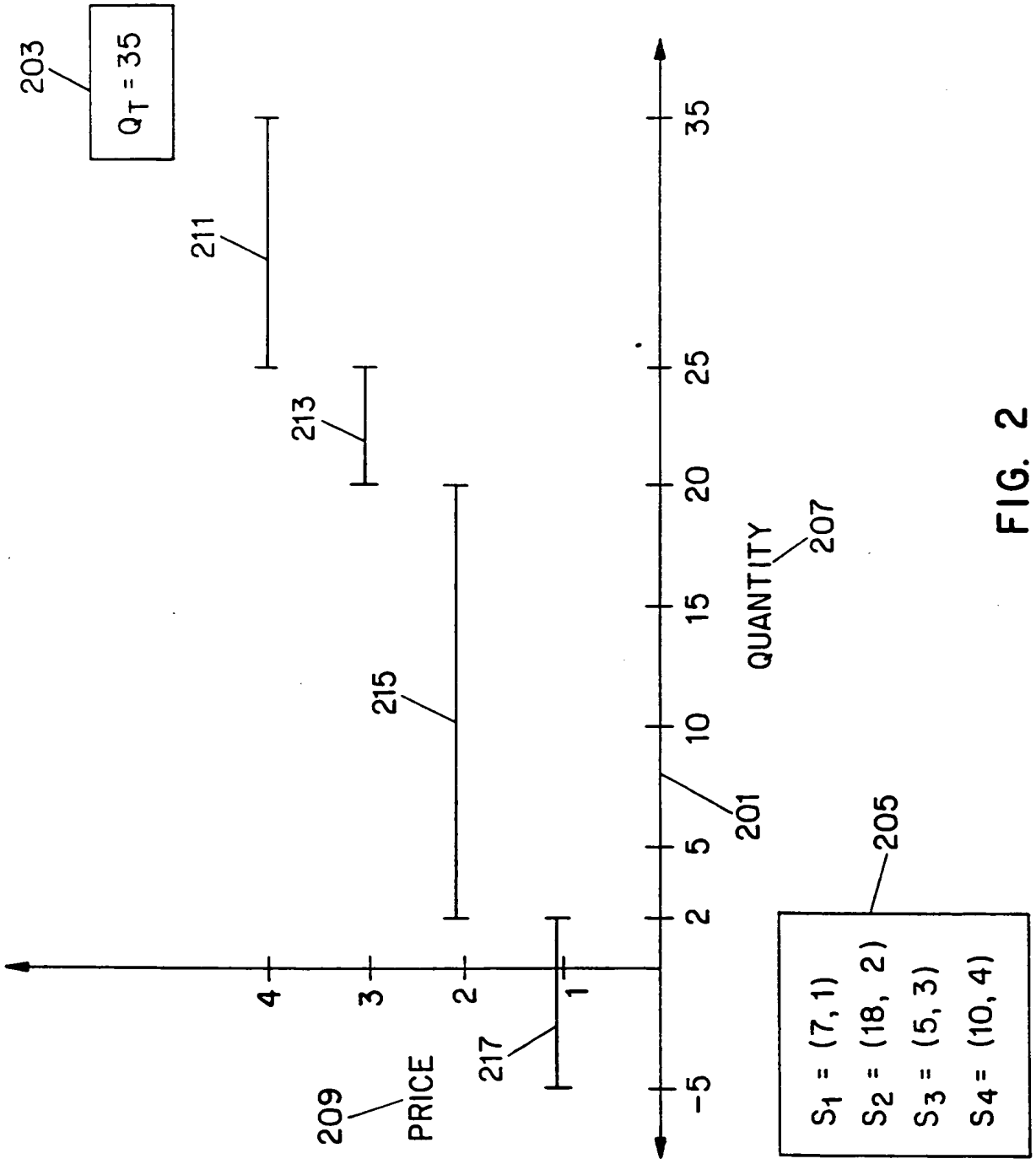
203
$Q_T = 35$
211
213
215
217
209
PRICE
4
3
2
1
201
QUANTITY
207
35
25
20
15
10
5
2
-5
205
$S_1 = (7, 1)$
$S_2 = (18, 2)$
$S_3 = (5, 3)$
$S_4 = (10, 4)$

FIG. 2

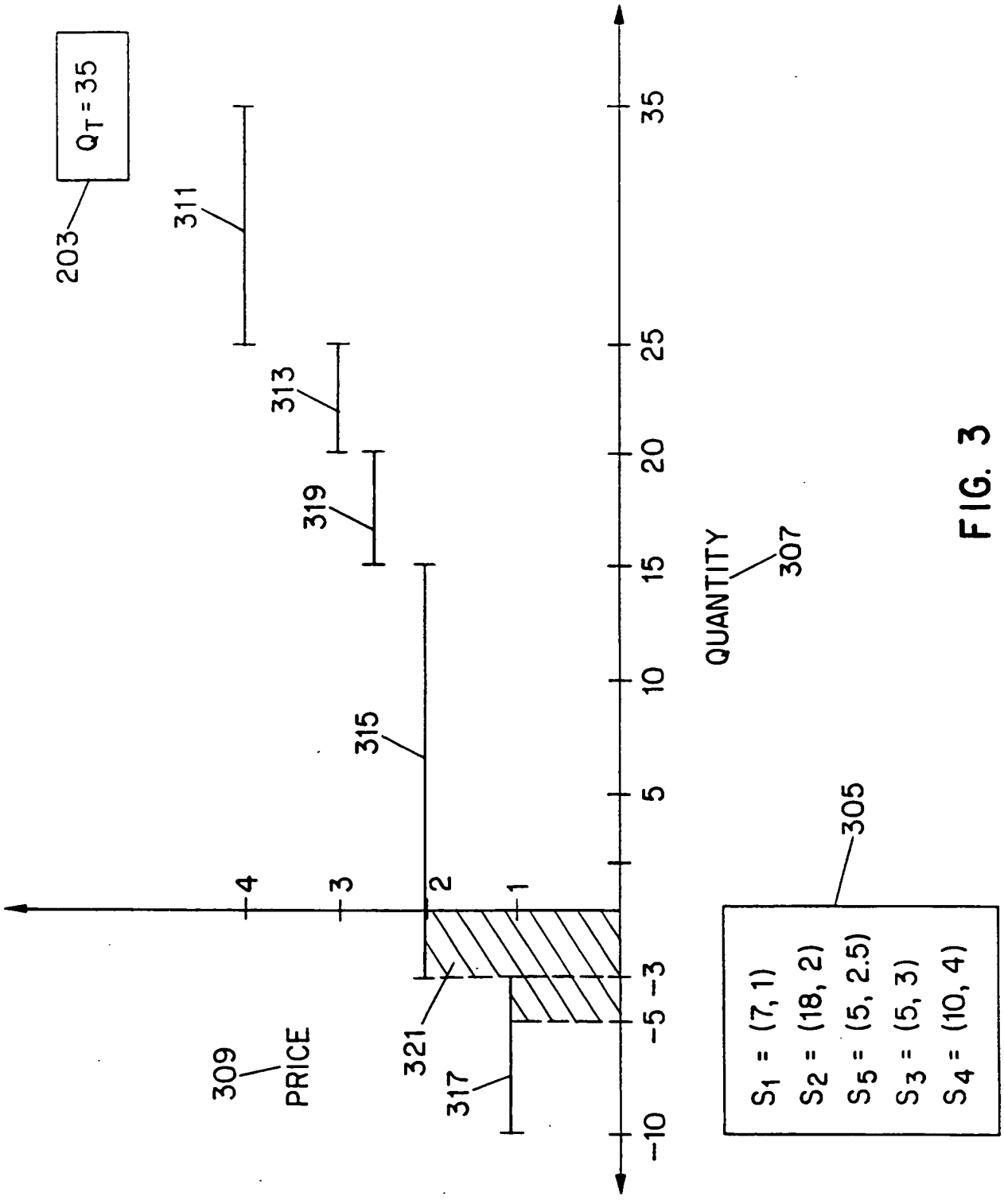
$Q_T = 35$
203
311
313
319
315
321
317
309
PRICE
4
3
2
1
35
25
20
15
10
5
−3
−5
−10
QUANTITY
307
305
$S_1 = (7, 1)$
$S_2 = (18, 2)$
$S_5 = (5, 2.5)$
$S_3 = (5, 3)$
$S_4 = (10, 4)$

FIG. 3

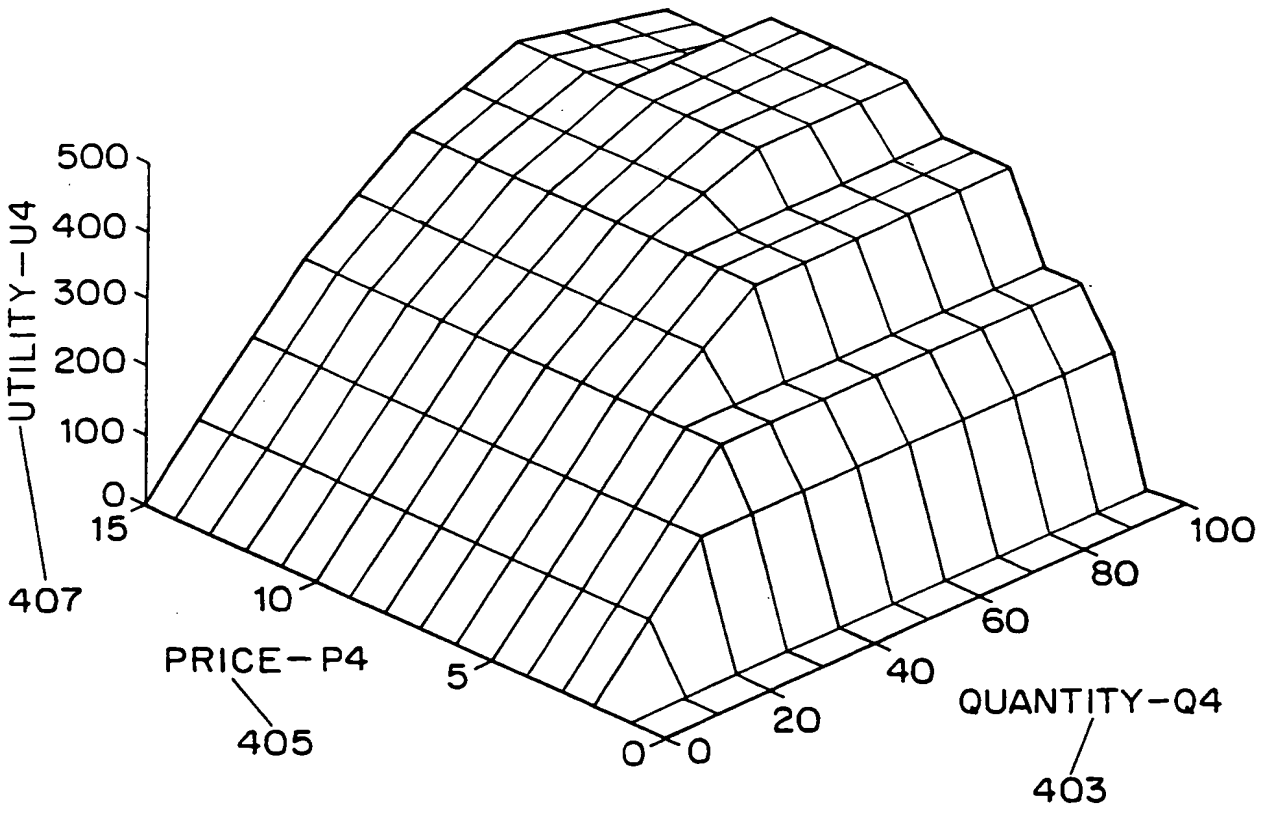
500
400
300
200
100
0
UTILITY-U4
407
15
10
5
0
PRICE-P4
405
0
20
40
60
80
100
QUANTITY-Q4
403

FIG. 4

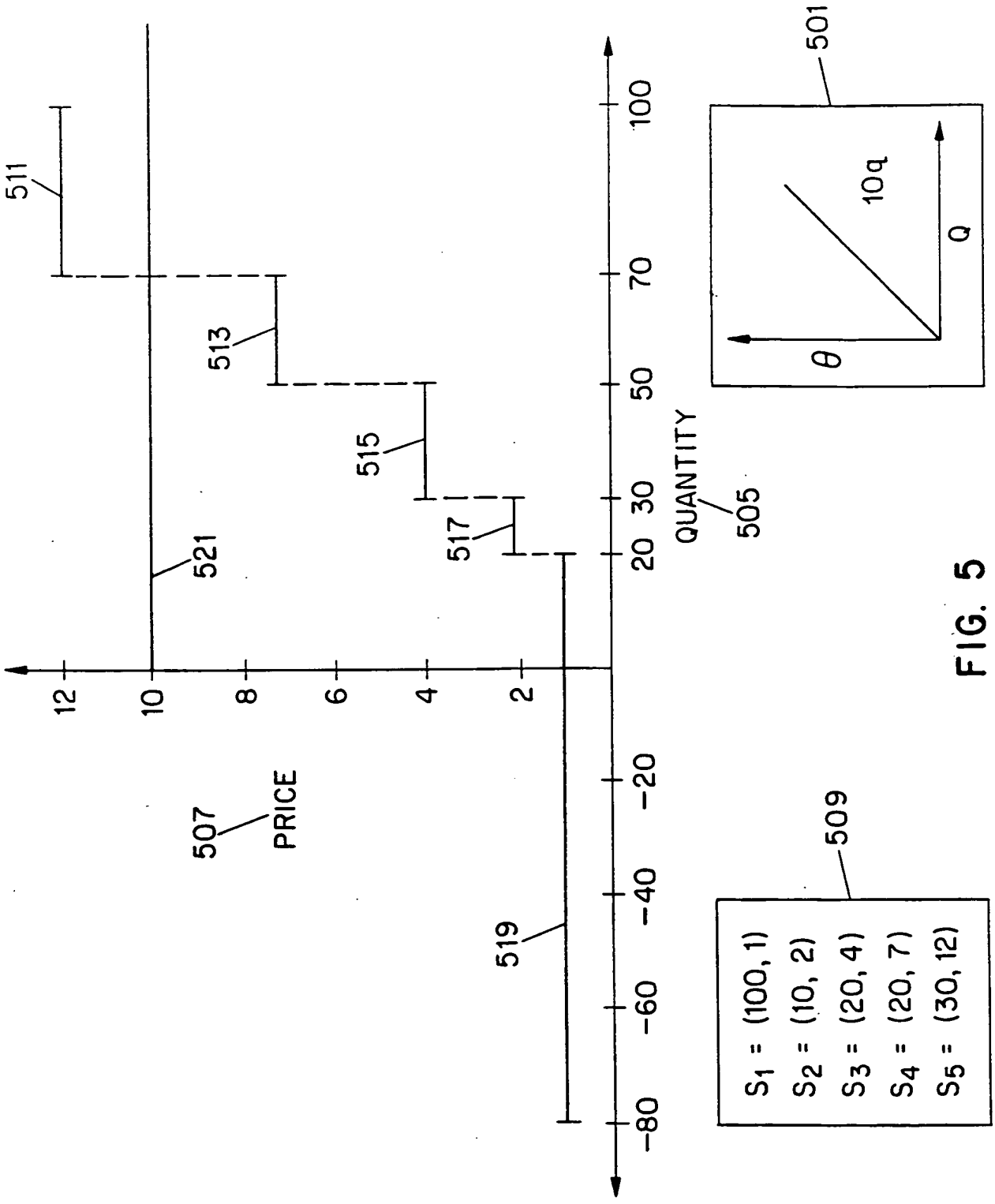
501
10q
Q
θ
511
513
515
517
519
521
507
PRICE
12
10
8
6
4
2
100
70
50
30
20
−20
−40
−60
−80
QUANTITY
505
509
S1 = (100, 1)
S2 = (10, 2)
S3 = (20, 4)
S4 = (20, 7)
S5 = (30, 12)

FIG. 5

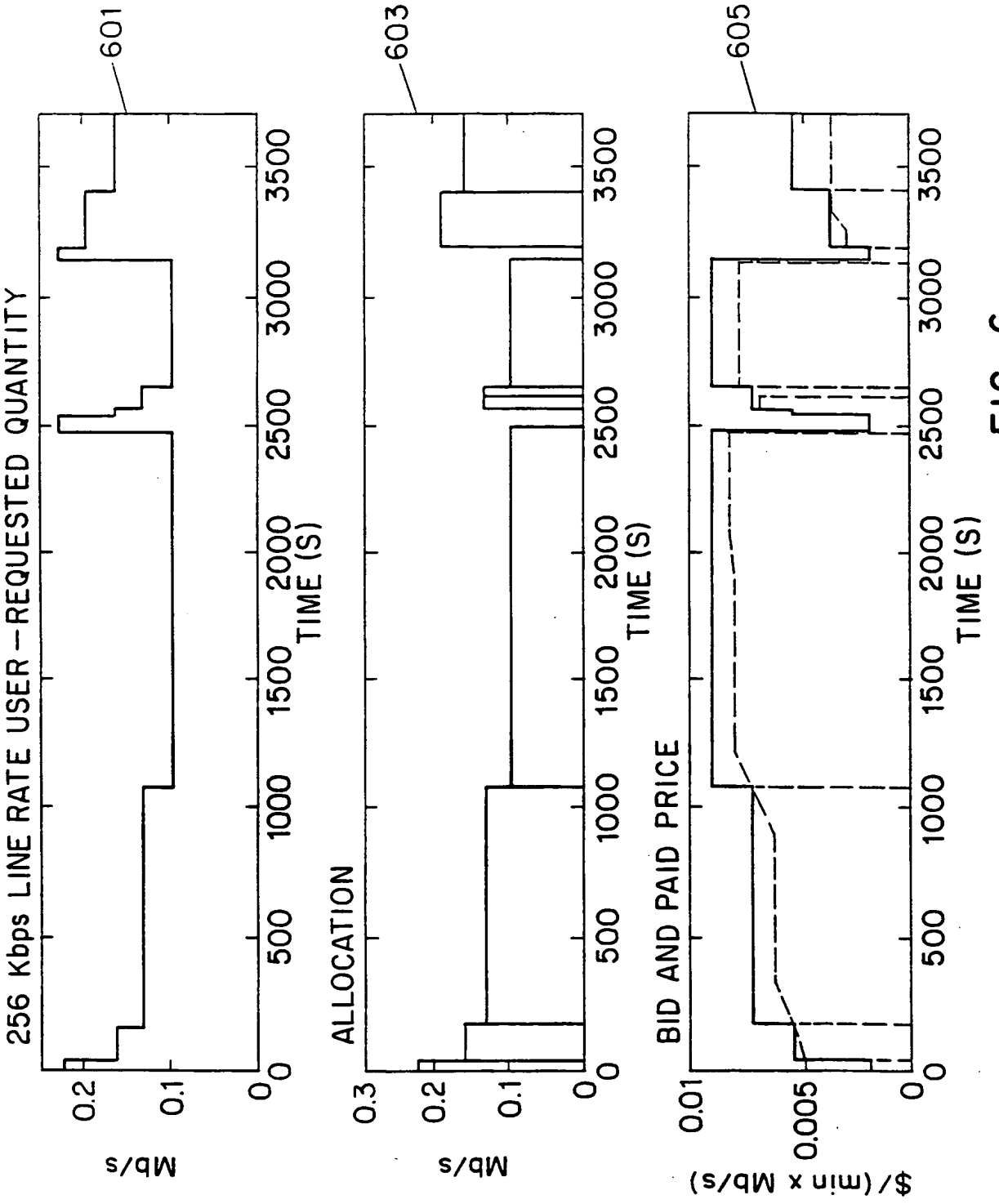
601
256 Kbps LINE RATE USER—REQUESTED QUANTITY
Mb/s
0.2
0.1
0
0
500
1000
1500
2000
2500
3000
3500
TIME (S)
603
ALLOCATION
Mb/s
0.3
0.2
0.1
0
0
500
1000
1500
2000
2500
3000
3500
TIME (S)
605
BID AND PAID PRICE
$/(min x Mb/s)
0.01
0.005
0
0
500
1000
1500
2000
2500
3000
3500
TIME (S)

FIG. 6

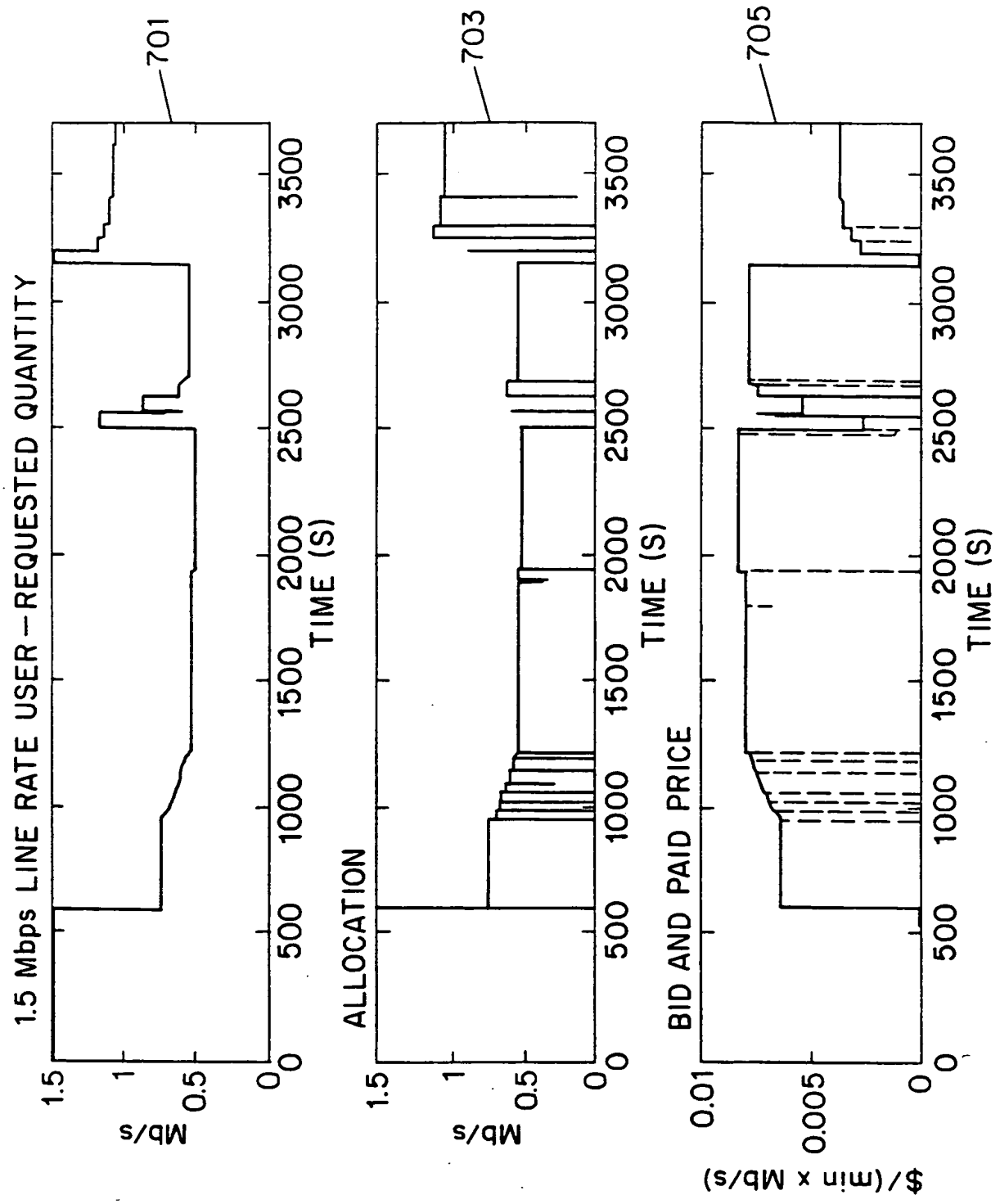
701
1.5 Mbps LINE RATE USER—REQUESTED QUANTITY
Mb/s
1.5
1
0.5
0
0
500
1000
1500
2000
2500
3000
3500
TIME (S)
703
ALLOCATION
Mb/s
1.5
1
0.5
0
0
500
1000
1500
2000
2500
3000
3500
TIME (S)
705
BID AND PAID PRICE
$/(min x Mb/s)
0.01
0.005
0
0
500
1000
1500
2000
2500
3000
3500
TIME (S)

FIG. 7

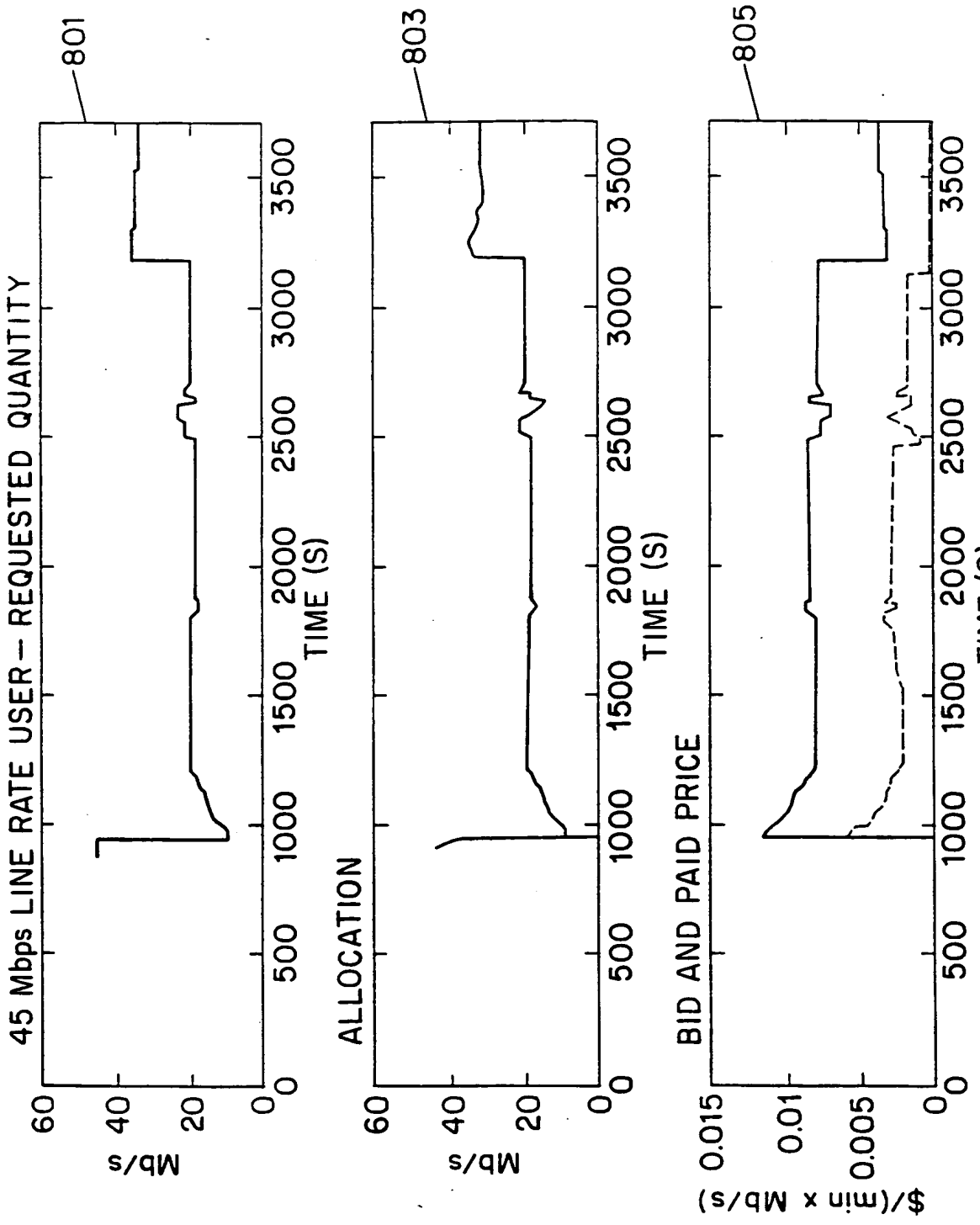
801
45 Mbps LINE RATE USER– REQUESTED QUANTITY
Mb/s
60
40
20
0
0
500
1000
1500
2000
2500
3000
3500
TIME (S)
803
ALLOCATION
Mb/s
60
40
20
0
0
500
1000
1500
2000
2500
3000
3500
TIME (S)
805
BID AND PAID PRICE
$/(min x Mb/s)
0.015
0.01
0.005
0
0
500
1000
1500
2000
2500
3000
3500
TIME (S)

FIG. 8

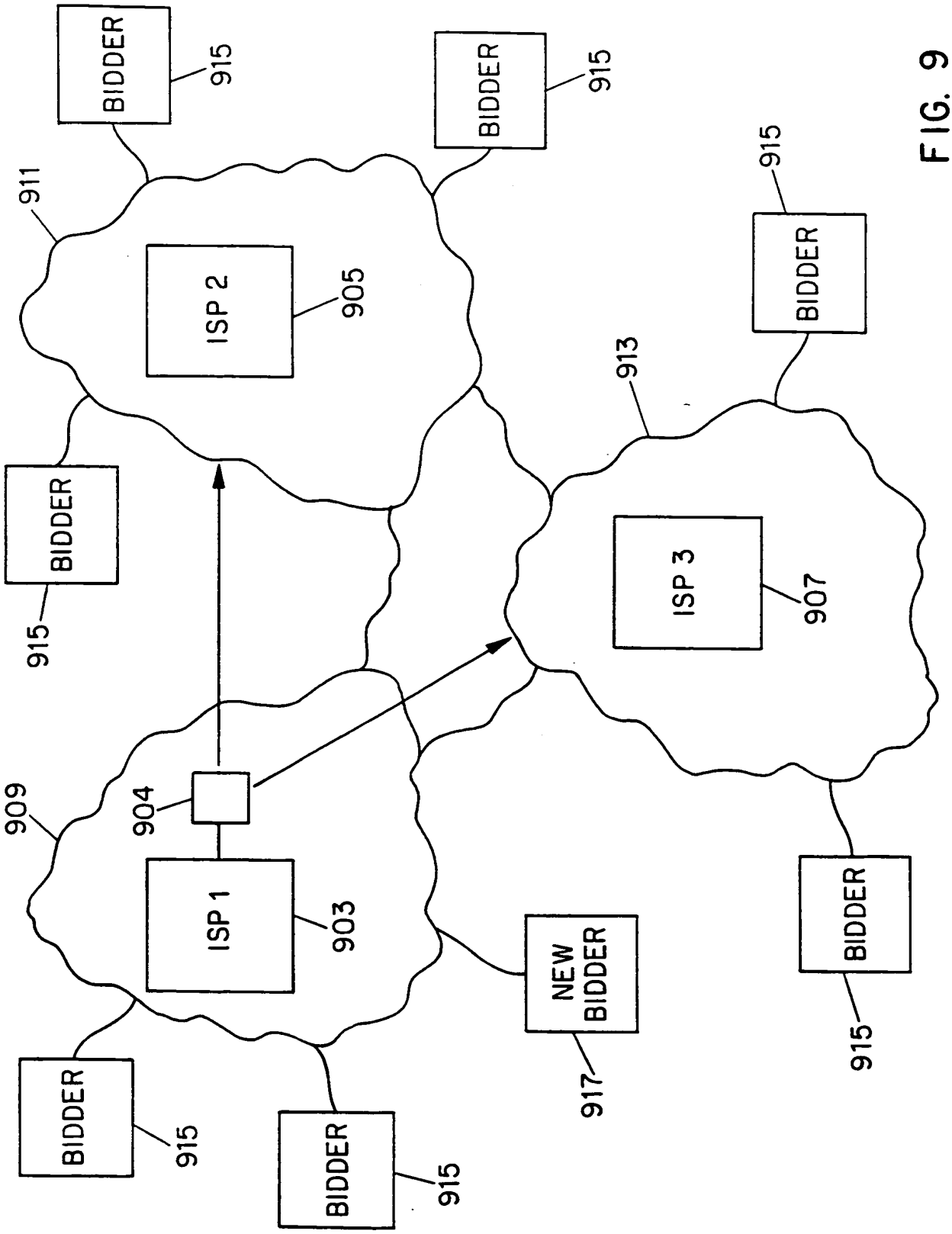
BIDDER
915
BIDDER
915
911
ISP 2
905
915
BIDDER
913
BIDDER
915
ISP 3
907
909
904
ISP 1
903
NEW BIDDER
917
BIDDER
915
BIDDER
915
BIDDER
915

FIG. 9

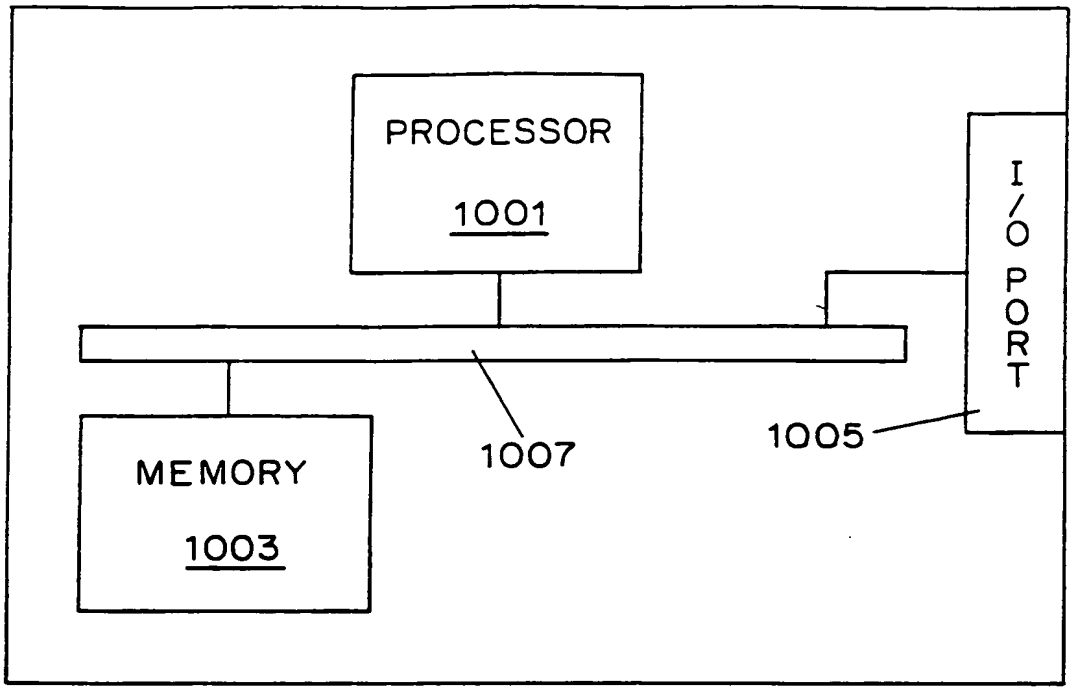

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No. PCT/US99/06384

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : G06F 17/60

US CL : 705/8, 37

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 705/7, 8, 37

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS (((negotiat? or bidd? or auction?) (5a) (bandwidth# or resource#)) and (internet or world()wide()web or www)), DIALOG (((second()price) (3n) (auction? or bidd?)) and next()high?)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FELDMAN, R.A., MEHRA, R. Auction: Theory and Applications. International Monetary Fund staff papers. September 1993, Vol. 40, No. 3, pages 485-511, especially pages 485-489.	1-42
A	ANONYMOUS, New Zealand Moves Toward Market Driven Spectrum Allocation. Spectrum Report, 01 February 1991, Vol. 1, No. 4, 1 page.	1-42
A	ANONYMOUS, Revenge of the Nerds: when government auctioneers need worldly advice, where can they turn ? To mathematical economists, of course. Economist, 23 July 1994, Vol. 332, No. 7873, page 70.	1-42
A	US 5,802,502 A (GELL et al.) 01 September 1998, see abstract.	1-42

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 08 MAY 1999	Date of mailing of the international search report 26 MAY 1999
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer EMANUEL TODD VOELTZ Telephone No. (703) [illegible]-9714

Form PCT/ISA/210 (second sheet)(July 1992) *

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/06384

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,640,569 A (MILLER et al) 17 June 1997, see abstract.	1-42
A	US 5,610,910 A (FOCSANEANU et al) 11 March 1997, see abstract.	1-42
A	US 5,487,168 A (GEINER et al) 23 January 1996, see abstract.	1-42